



U.S. Department of Energy | Office of Science

# **HYPERFACETS**

A Framework for Improving Analysis and Modeling of Earth System and Intersectoral Dynamics at Regional Scales



## **IMPROVING MODELING OF EARTH SYSTEM AND INTERSECTORAL DYNAMICS AT LOCAL SCALES: HURRICANE STORYLINES**

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# *HyperFACETS Motivation*

**Actionable climate science** relies on effective communication of **regional climate information** and its **associated uncertainties**. In light of future uncertainty, it is absolutely necessary to **build trust in climate models and climate data**.

**We want to objectively address the questions:**

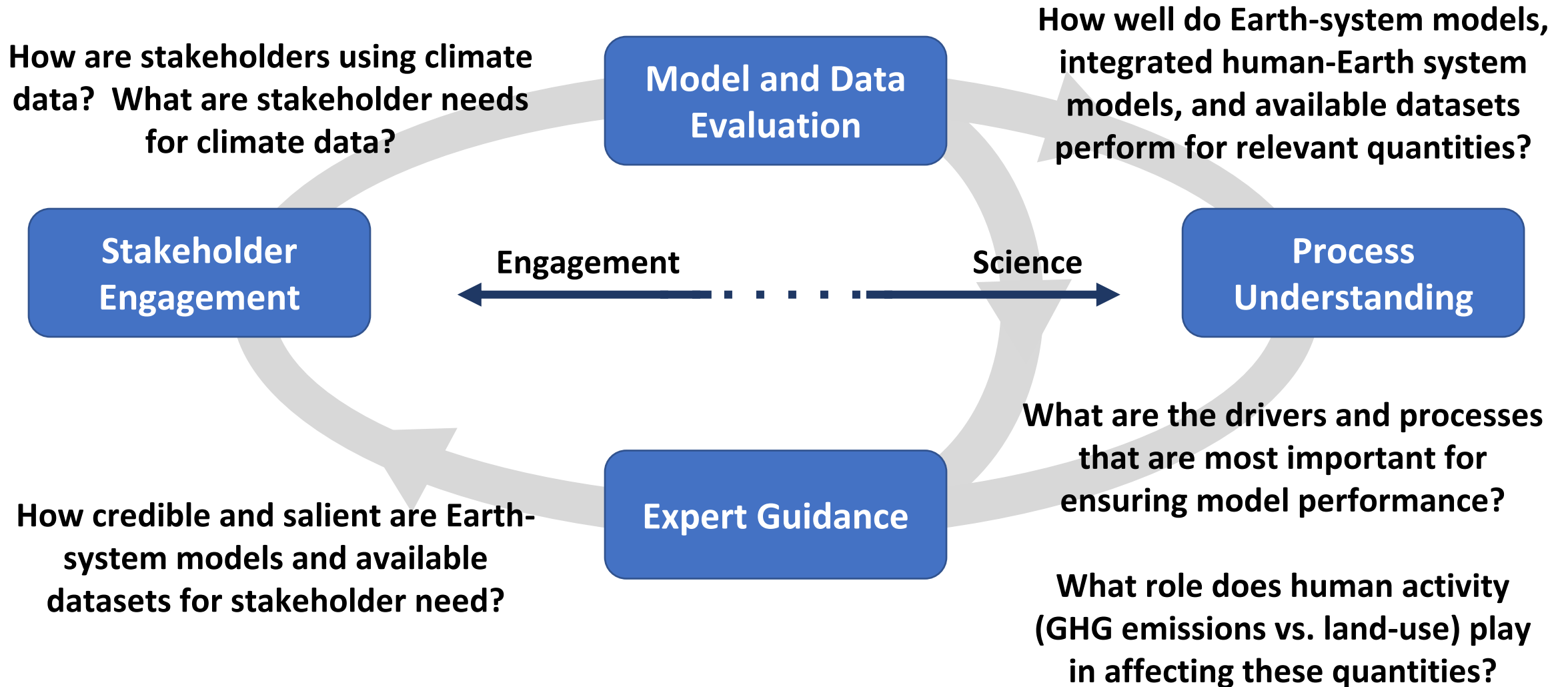
How much can we trust given climate information for actionable climate science?  
How can we ensure its saliency?

We normally say that a climate dataset is **credible** if it can **accurately reproduce historical climatology** (for example, average conditions and extreme events/periods) and it **gets the answer for the right reasons** (by capturing relevant processes, crucial for ensuring trust in future projections).

# *HyperFACETS Project Goals*

1. Advance our understanding of processes at the atmosphere-water-energy-land interface.
2. Fundamentally understand and evaluate our ability to perform credible climate modeling of particular regions and their associated processes, especially in the extreme.
3. Strengthen stakeholder engagement in model development, evaluation and application. Engage effectively in co-production: Together enforcing the science and meeting real needs.

# Achieving Project Goals via Continuous Engagement

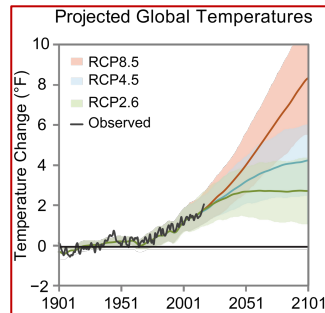
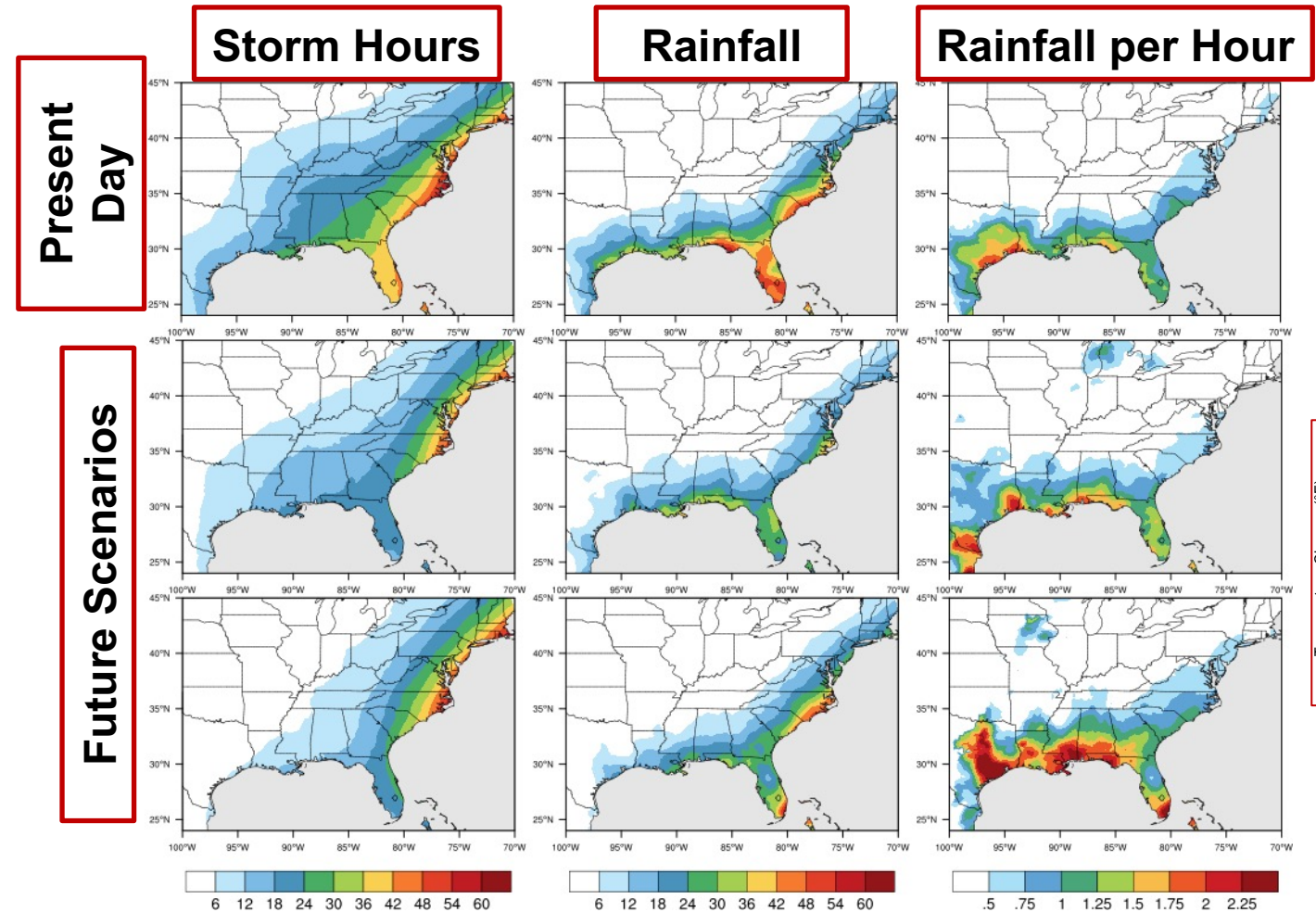


# Traditional Approach: Hurricane Precipitation

General **decrease in storm hours** over land, which is consistent with a decrease in TC frequency.

Projections are mixed when looking at rainfall from TCs.

The amount of TC-related extreme precipitation (and TC-related precipitation in general) **increases per storm hour!**



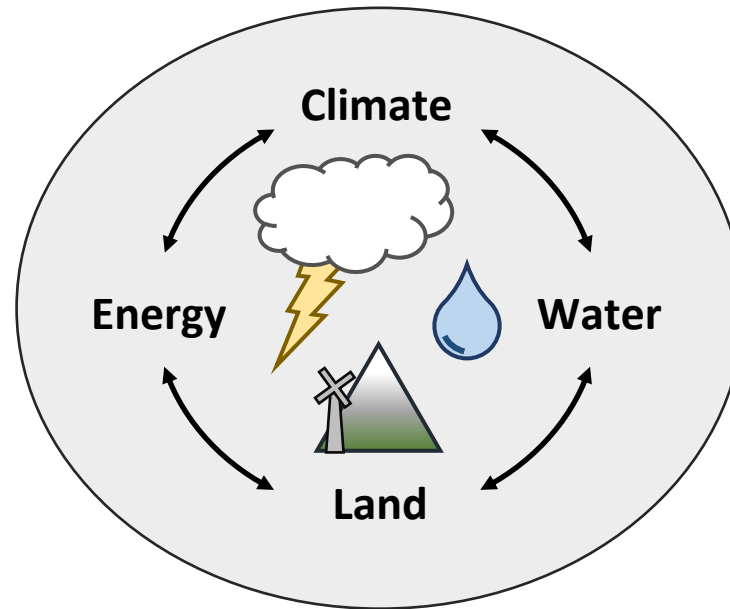
# HyperFACETS Science Approach

## Storylines

Focus on tangible events that have produced significant impacts.

## Multi-Sector Interactions

Understand the two-way interactions between the human and Earth system.



## Process Understanding

Deepen our understanding of the processes that connect the physical system.

## Differential Credibility Analysis

Assess our ability to correctly model the processes in the physical system.

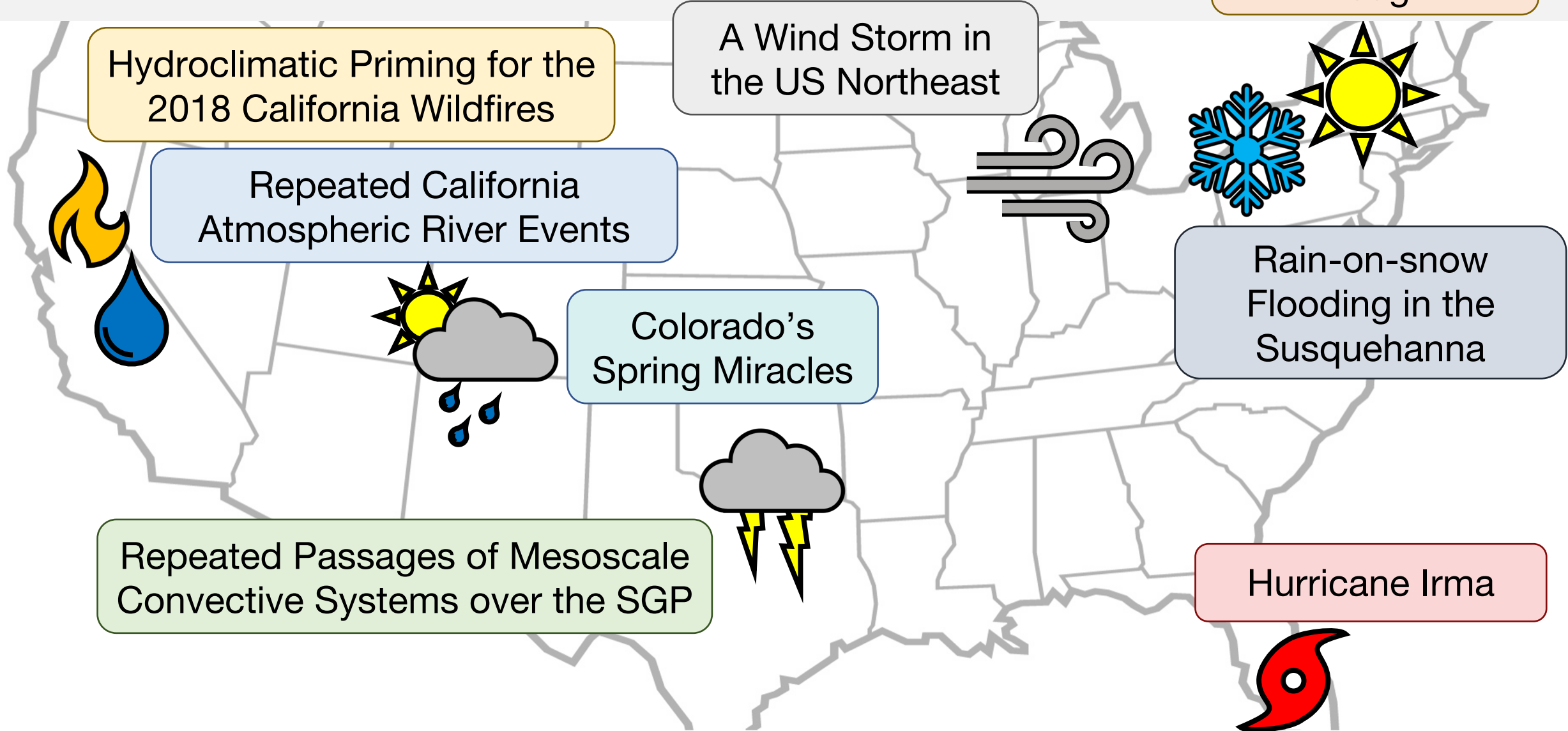
# Selecting Storylines

- Historic events with **significant socioeconomic impacts**
- Events that **stakeholders / practitioners are using for future planning**
- Events which are **most significantly lacking in available data**  
...or events where more information has the greatest potential to shape decision making
- Events with synergies **across regions / groups** when it comes to the salience of our conclusions
- Events where there is a need for deeper **process understanding**

## Related concepts:

- **Synthetic storylines** can also be explored; these do not correspond to historical events.
- **Anthologies** are groups of storylines that are similar in geography or character.

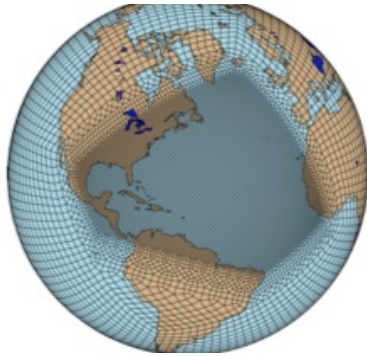
# HyperFACETS Storylines





# ***Storyline Approach: Hurricane Irma***

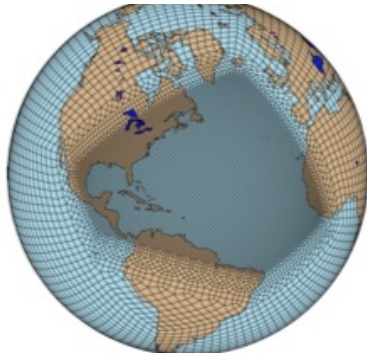
- **Configure climate model to run in hindcast mode. Implement with the same variable-resolution grid from climate-scale analysis:**



- **How does storm rainfall change for Hurricane Irma?**

# Storyline Approach: Hurricane Irma

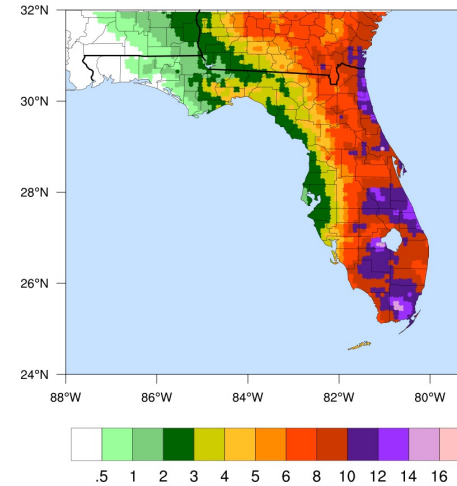
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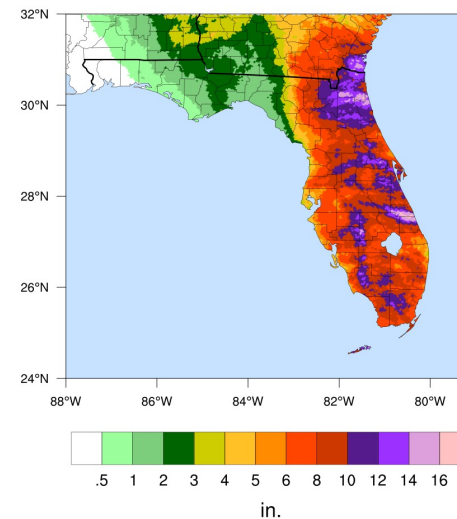
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Obs.

GPM Observed Precipitation (9/09-9/12/2017)

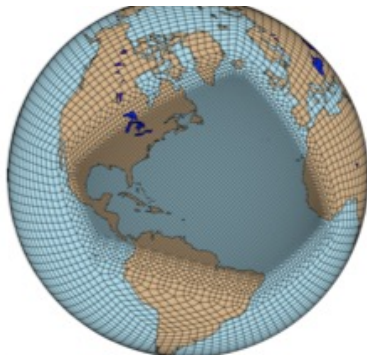


Total Observed Precipitation (9/09-9/12/2017)



# Storyline Approach: Hurricane Irma

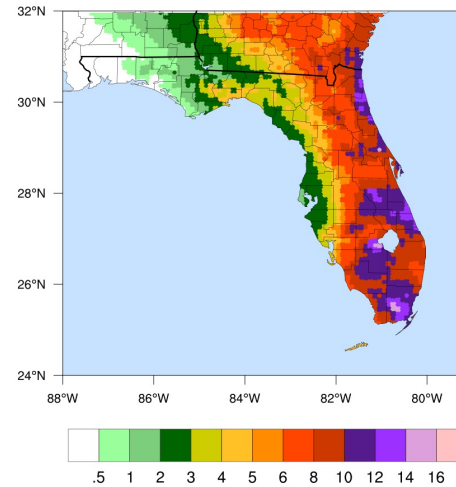
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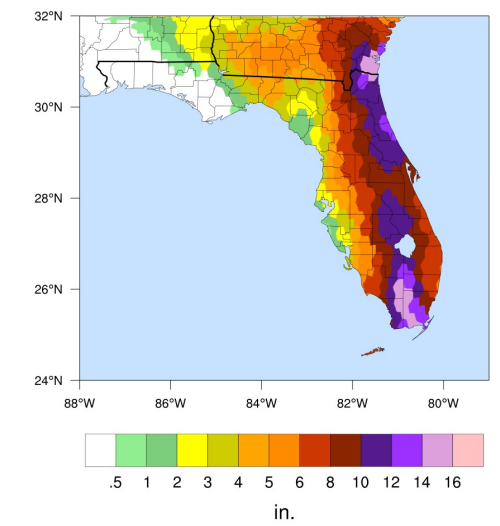
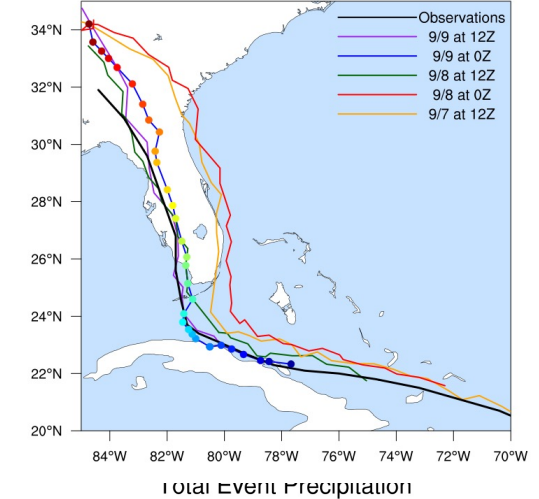
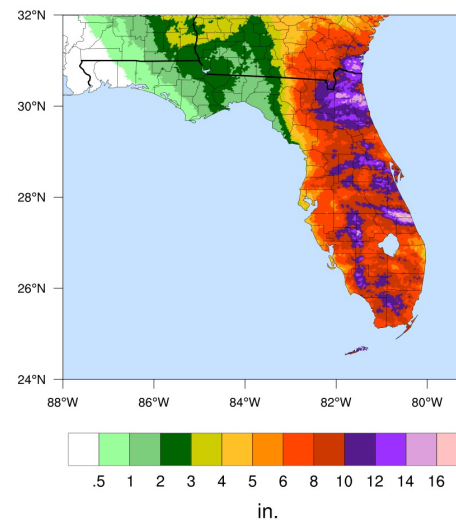
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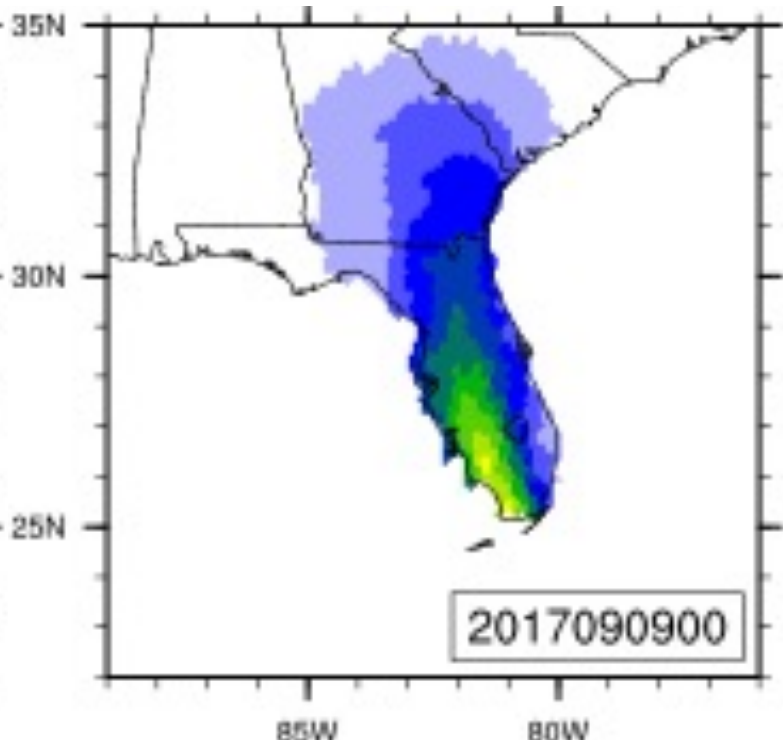
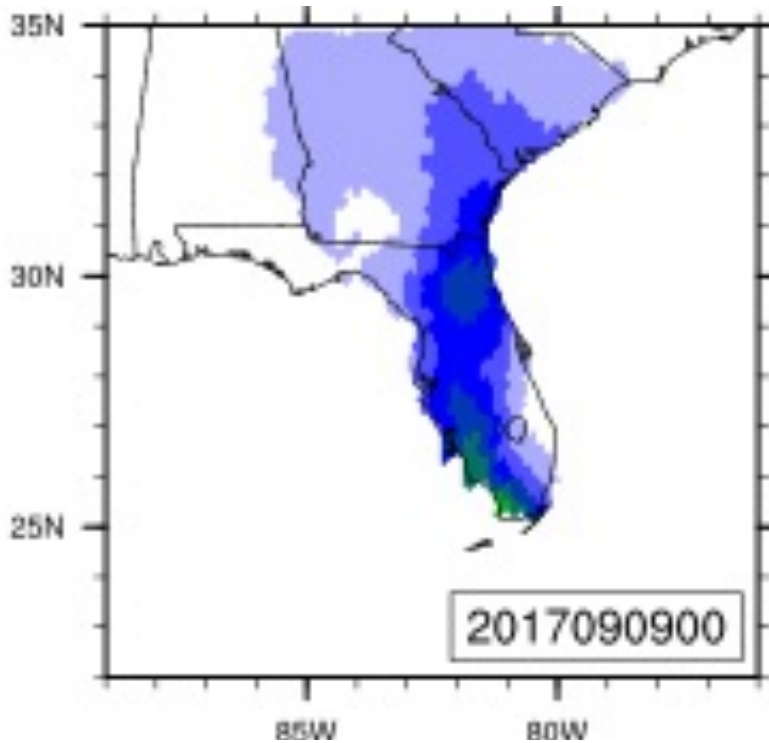


Climate Model Hindcast

# Storyline Approach: Hurricane Irma

2017 (Present)

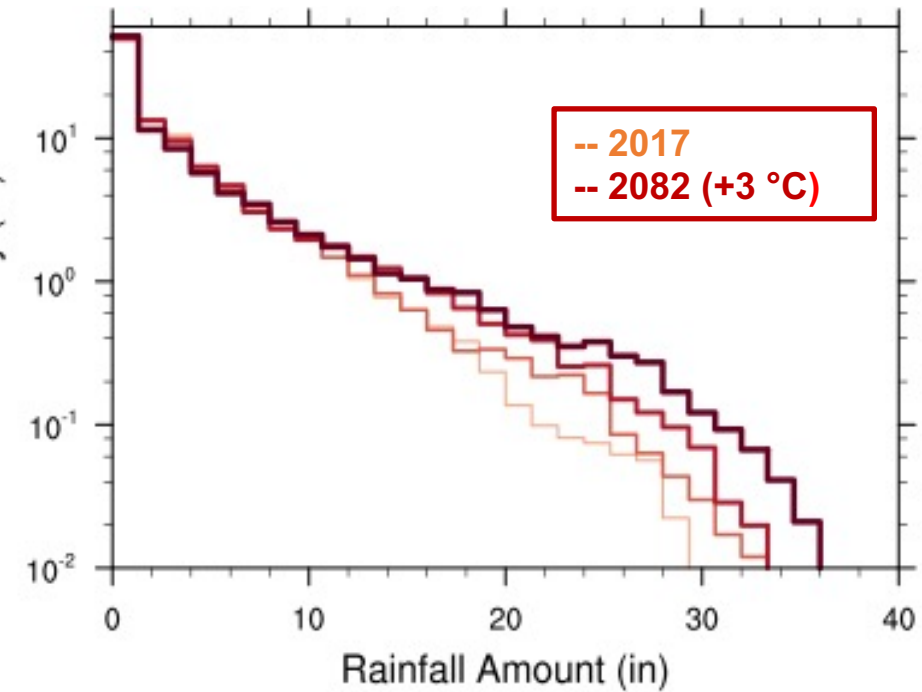
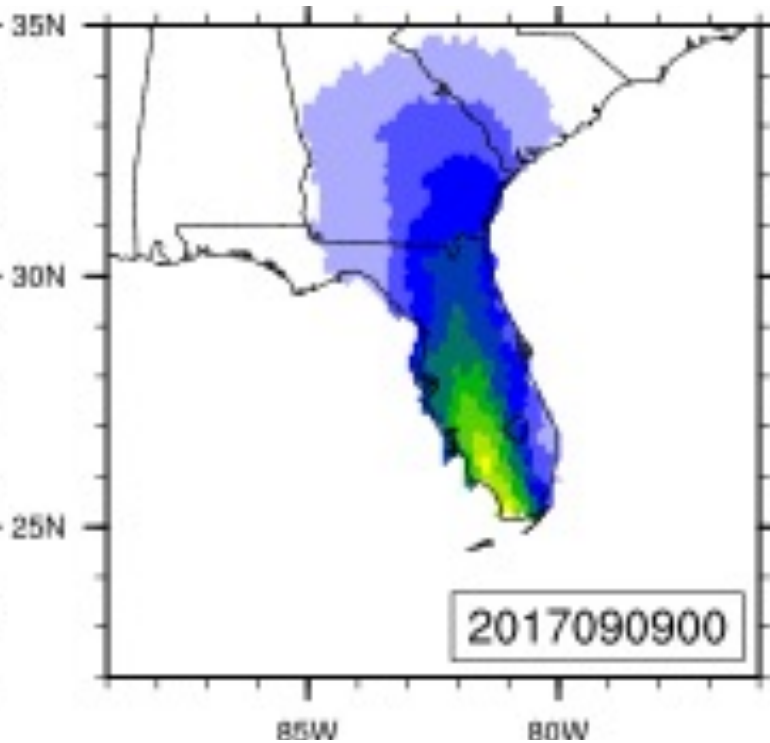
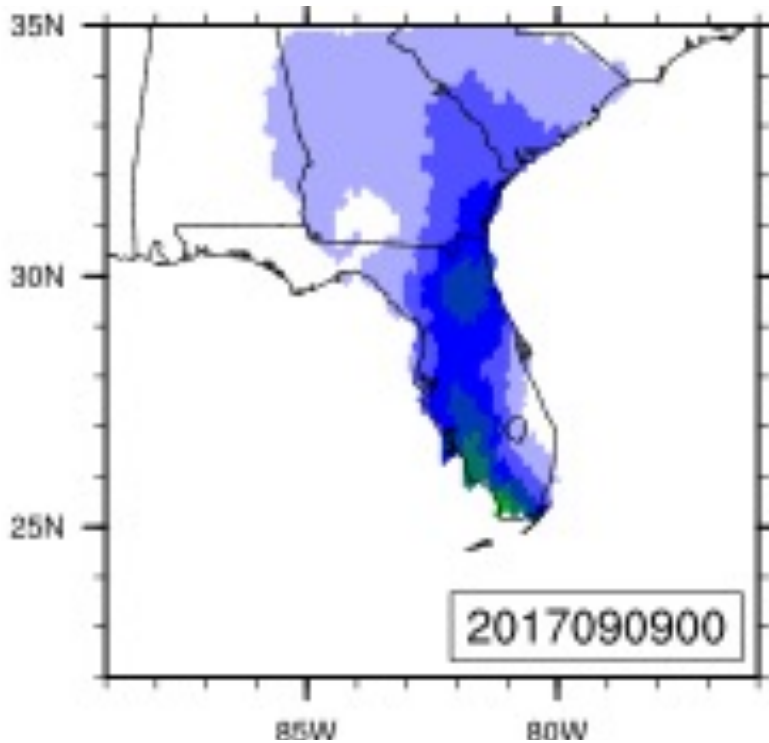
2082 (+3 °C)



# Storyline Approach: Hurricane Irma

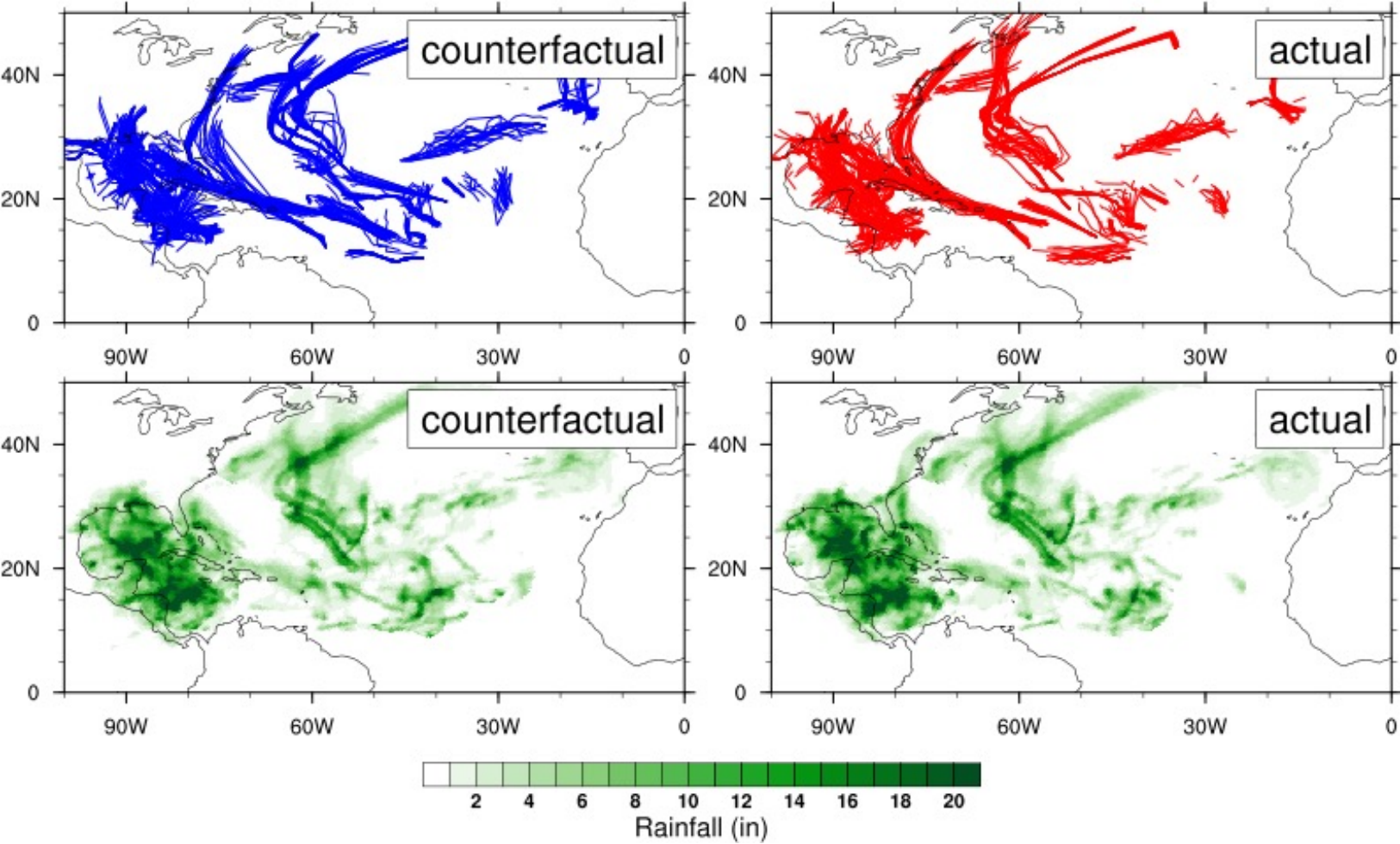
2017 (Present)

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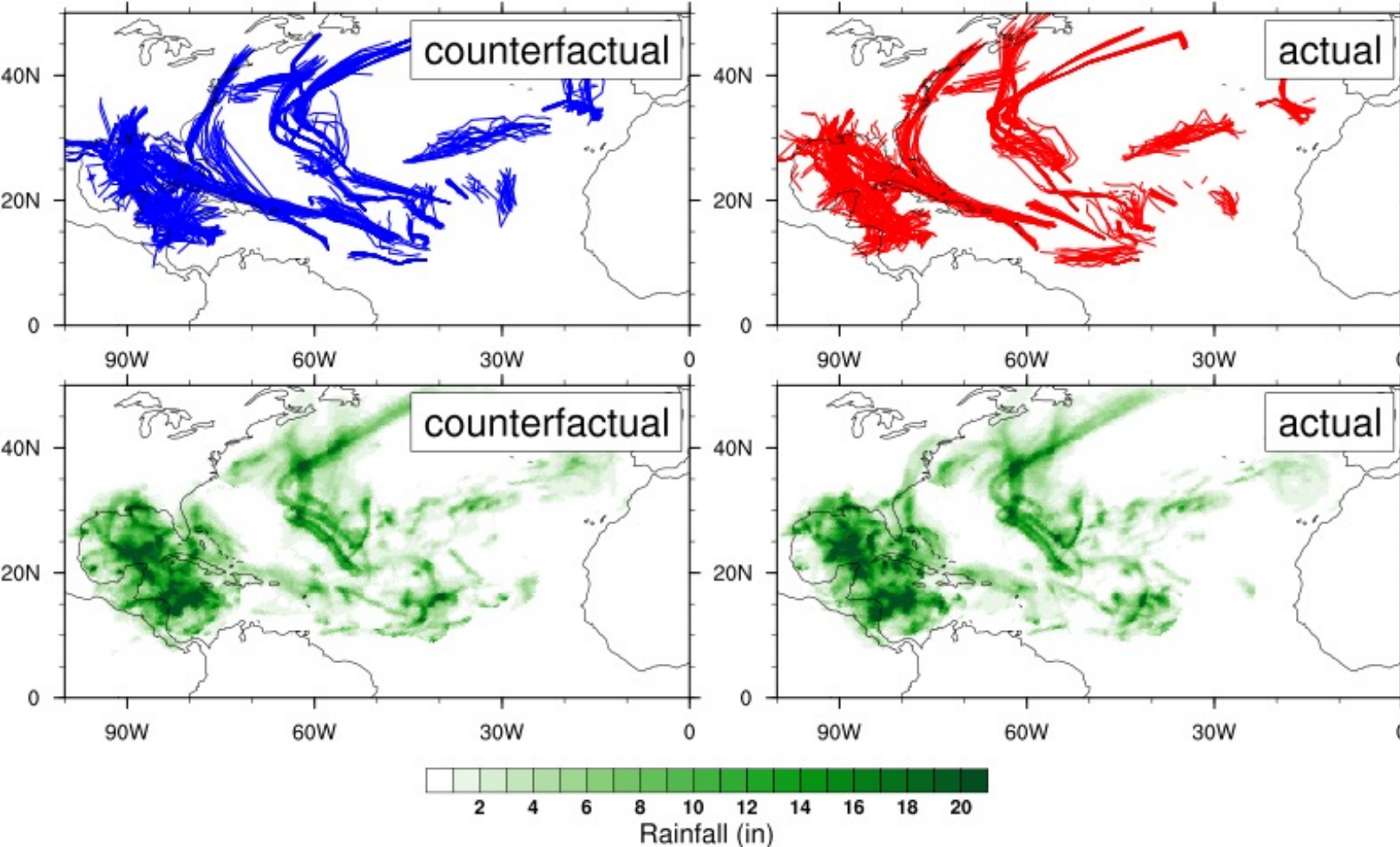


**~26 ± 6% increase in simulated extreme rainfall amounts.**

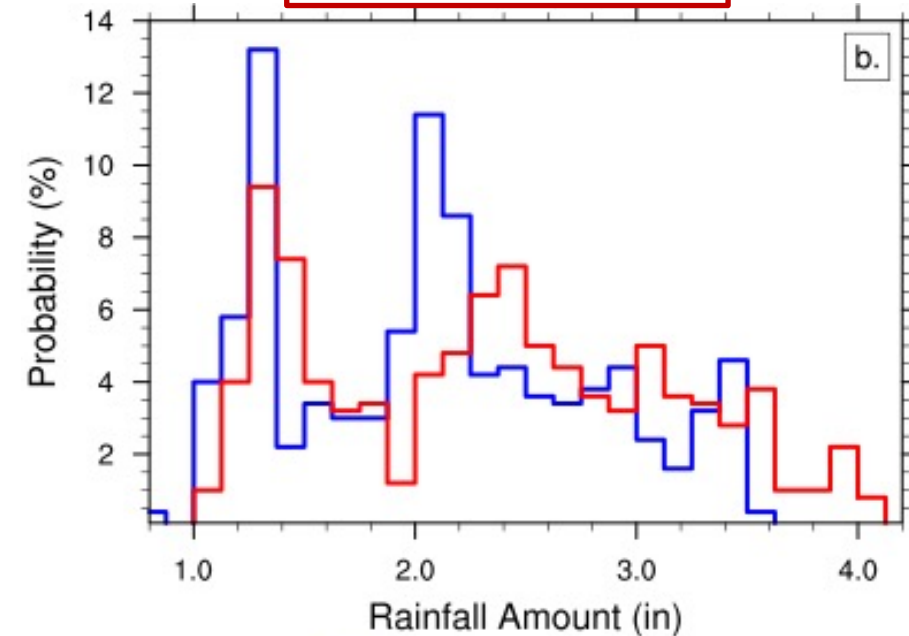
# Storyline Approach: Operational Attribution



# Storyline Approach: Operational Attribution



99 percentile  
3-hr Rainfall  
Amounts



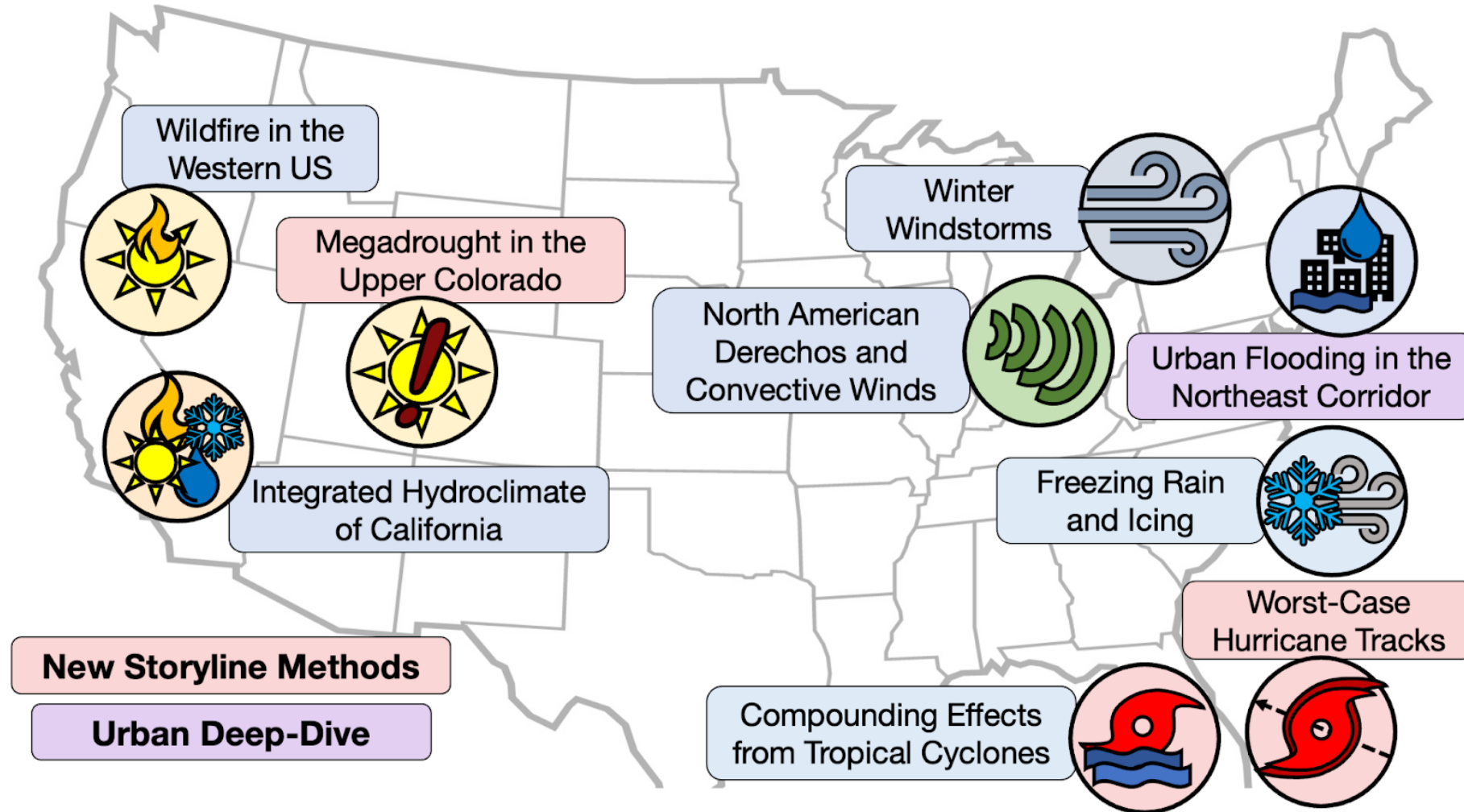
A shift of  $\sim 10 \pm 5\%$  in most extreme rainfall rates.

# Takeaways

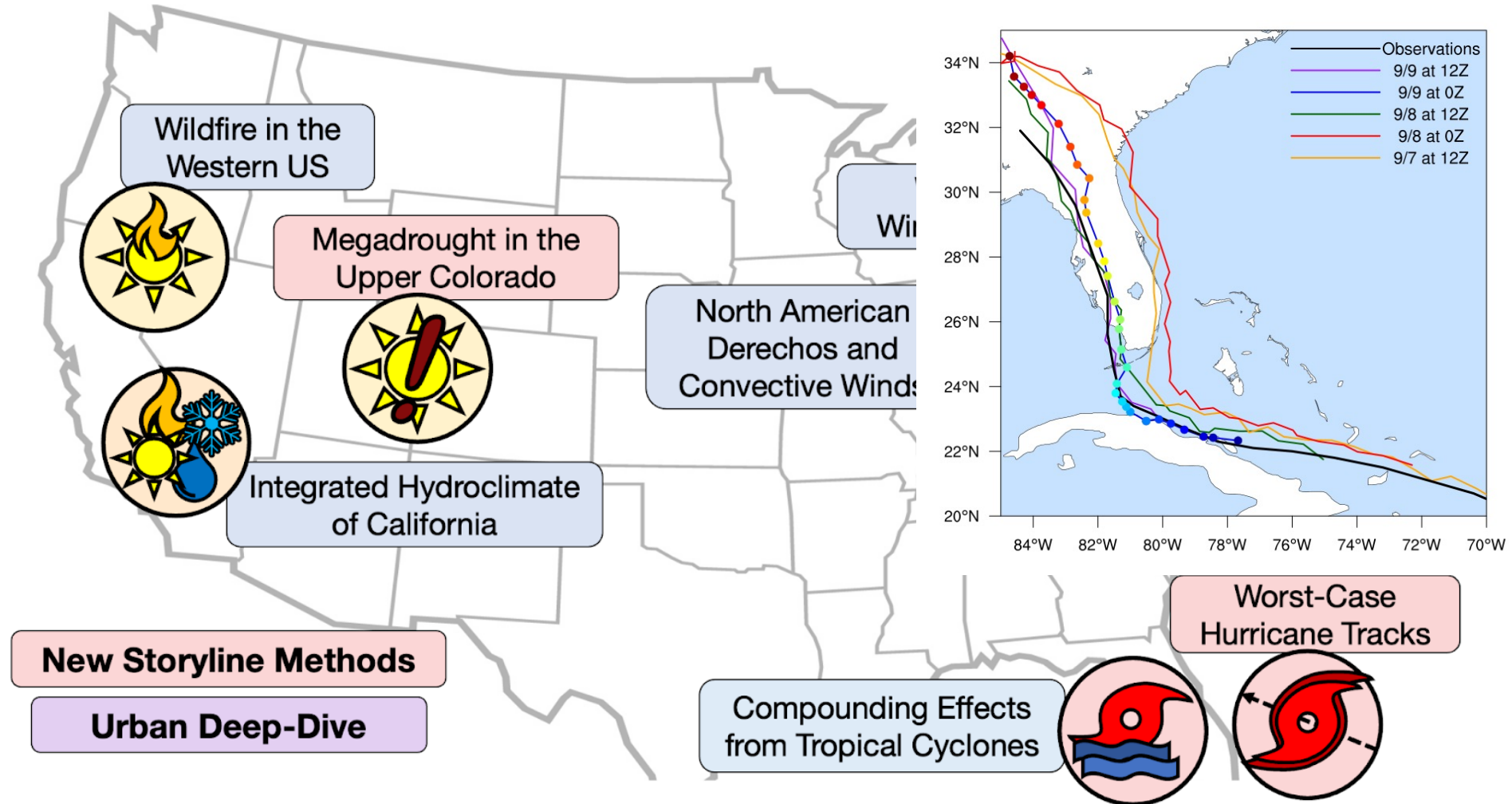
- The combination of traditional (decadal trends) and storyline approaches suggest a consistent conclusion: **TC rainfall per hour of storm impact will increase under a warming climate.**
- There is a growing effort in the scientific community – with direct stakeholder needs – to quantify the impact of climate change on recent extreme events and how these events will change in the future. **Storylines are a promising approach.**
- Work suggests there is a pathway toward **operational storyline frameworks** in the future.



# Future Work – Expanding Storyline Approaches



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**Thanks!**

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# ***Modeling Storylines***

## **Pseudo Global Warming (also Imposed Global Warming)**

- Model the historical event using forcing from reanalysis data
- Assess expected change to thermodynamics (and optionally dynamics) due to climate change
- Impose these changes at a coarse level and re-simulate the historical event
- Instead of imposing global warming, we can instead impose land-use land-cover change (LULCC)

## **Direct Downscaling**

- Identify events in, e.g. CMIP data, that have similar character to the event being studied
- Use downscaling to obtain a representation of the events at high resolution
- Repeat over multiple events to obtain a sufficient statistical sample

## **Large Ensembles**

- Evaluate the statistics of analogous events over the large ensemble